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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Outboard Motors and Their Operation

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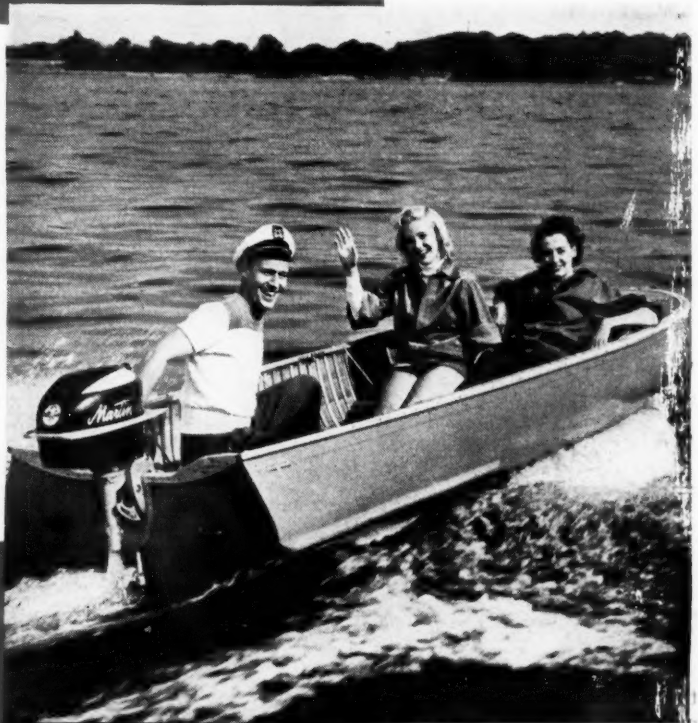

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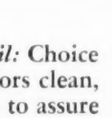

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LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

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Outboard Motors and Their Operation

THE snarl of a wide open motor early in the morning may shatter your well deserved rest and lead to promises to practice mayhem on the disturber of the peace, or the soft hum of a smoothly idling motor may locate the fisherman trying for that last "big one" at sunset. In either case, one is conscious of the application of controlled power.

Let us look at some of the factors which influence this controlled power, starting with the two types of gasoline engines which are, or can be, employed so that a comparison of them may be made.

THE PRINCIPLES INVOLVED

Engines employing the four-stroke cycle principle are most commonly used in automobiles; they require two revolutions of the crankshaft to complete one operating cycle. The fuel mixture is introduced through openings controlled by valves while the piston is going down. When sufficient fuel has been introduced the valves are timed to close and the upward movement of the piston compresses this mixture. At the proper instant, controlled by the spark setting, the spark plug fires and the combustion and expansion of the gas transfers power to the piston to force it down. The burning mixture is then expelled into the manifold, through ports controlled by valves, during the next upward movement of the piston. The four movements of the piston through intake, compression, power, and exhaust give the four cycle engine its name. This type engine may be lubricated either by a splash or a force feed system from the oil supply carried in the crankcase.

The two-stroke cycle principle is more commonly used in outboard motors. In this type of engine, the operating cycle is completed in one revolution of the crankshaft. The fuel mixture is introduced (usually to the crankcase through valves and into the cylinder through ports located in the lower part of the cylinder which are uncovered as the piston travels toward the bottom of its stroke) and compressed on the upper movement of the piston. At the proper instant the mixture is fired by the spark plug, and power is imparted to the piston which is forced down. During the downward movement of the piston the exhaust ports are also uncovered to vent the exhaust gases. The number of strokes has thus been reduced to two, intake and compression on the upward stroke, with power and exhaust on the downward stroke, thus giving the two-stroke cycle engine its name. In these engines the lubricant is mixed with and carried by the fuel into the engine through the crankcase. As the oil enters the crankcase it is in a very finely divided state and in this form bathes the bearings and other moving surfaces with a protective film. An equilibrium is soon established within the engine, balancing oil requirements against the oil supplied. Any oil not required for lubrication continues to be carried with the fuel and is burned rather than dropped out to accumulate in the engine.

There are several advantages in using the two-

Courtesy Chris-Craft Corporation

Figure 1 — Exterior view of Chris-Craft 5.5 H.P. Outboard Motor.

cycle principle in outboard motors. One of the main reasons being the good ratio of horsepower to weight, resulting from twice as many power strokes in the two-cycle engine as there are with the four-cycle engine for any given number of revolutions. Other advantages would include the elimination or reduction of complex valve, lubricating, and electrical systems, all of which add weight.

In the above paragraphs the combustion process was lightly covered, mentioning only that a fuel mixture is introduced and that the spark is furnished at the proper instant to give the desired performance characteristics. In the case of the two cycle engine an additional few words appear warranted.

In most gasoline engines the speed of the engine is controlled by the throttle setting. When the volume of the fuel charge is reduced by closing the throttle, the engine speed is reduced and there is a reduction in engine power output. In the two cycle engine the burned gases are scavenged by the entry of the fresh charge, and if the volume of this fresh charge is reduced too greatly, the old mixture is not swept out and a gas mixture is furnished which is not combustible. When such a condition arises, it is necessary to increase the volume of the new charge to secure a combustible mixture. Since the introduction of an increased fuel volume would normally increase speed and power output, which in this case is not desired, the spark timing is retarded so that only a small amount of power is delivered from the relatively large fresh fuel charge. The size of the incoming fuel charge and the point to which the spark must be retarded to obtain the best operation (not only in low speed operation but throughout the full range) is determined experimentally during the development of the engine by the manufacturer. Once this synchronization of timing and fuel volume has been established, conditions are set at the factory to maintain this relationship and they can not be adjusted by the operator.

Before entering upon a discussion of the effect of the several variables connected with outboard motor operation, one point must be emphasized. No one factor can be segregated and considered as a separate entity, rather all the factors must be considered as a part contributing a portion to the whole. The engine design, the fuel, and the lubricating oil must be mutually compatible, and furnish a satisfactory answer to the requirements of the operator.

BEARINGS

Good design is essential in the outboard motor and an example of this is clearly indicated when one reviews the number and types of bearings which are used in engine construction. When considering what bearing to use, the designing engineer endeavors to select the one which will cost the least and yet will meet the performance requirements. A cross section of one of the larger horsepower models is shown in Figure 3.

The top and bottom journal bearings, identified as No. 1, may be either one of two types having caged roller bearings or loose roller bearings. These bearings were chosen as they lend themselves to satisfactory sealing, which is a definite problem

Figure 2 — Exploded view of crankshaft assembly: 1. Fly wheel, 4. Plate, Reed stop, 5. Reed set, 6. Center main bearing assembly, 8. Crankshaft, 9. Key, fly wheel. *Courtesy Kiekhaefer Corporation*

Figure 3 — Cross section of Johnson 25 H.P. Engine showing location of different bearings.

Figure 4 — Showing journal bearing assembly and carbon "face type" seal.

Figure 5—Bearing retainer showing flange which protects against burning of the side thrust face.

Courtesy Johnson Motors

Figure 2

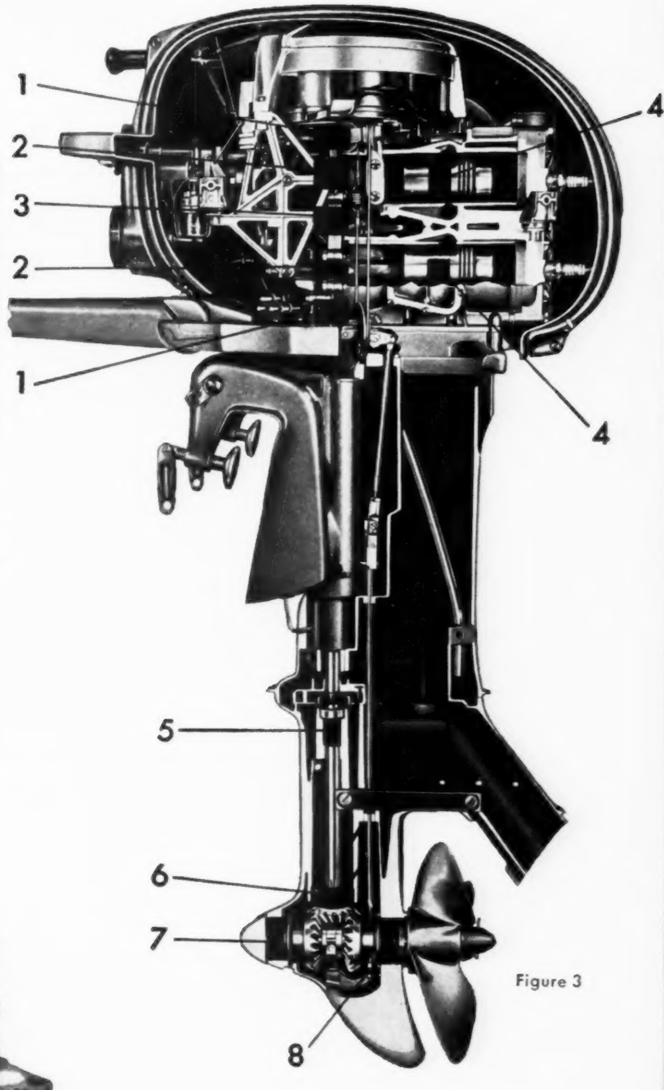


Figure 3

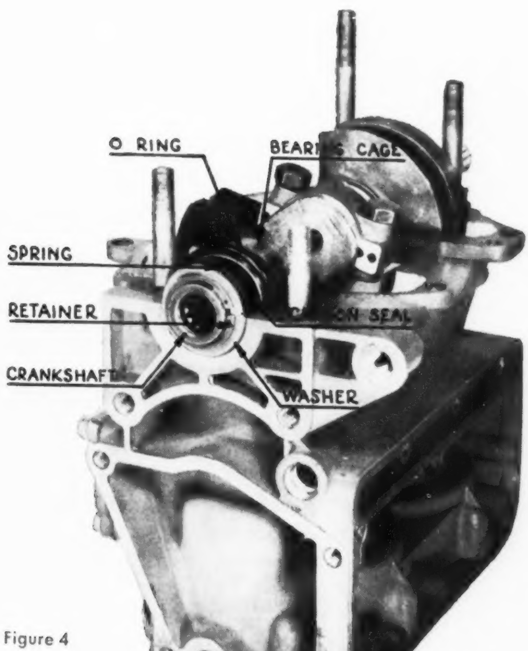


Figure 4

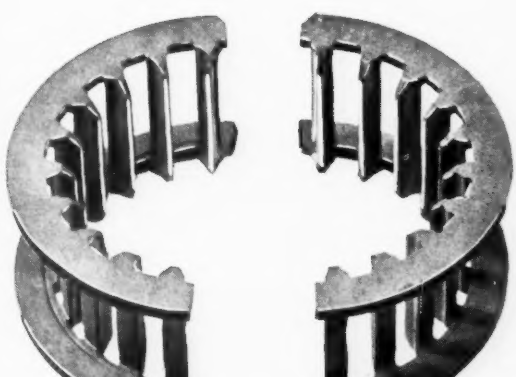


Figure 5

under the very high speeds and the methods of scavenging employed in two cycle engines. The bearing race receives the carbon "face type" seal and since alignment is good, either the caged or loose rollers may be used.

No. 2, the connecting rod shaft bearings, are caged roller bearings with a single roller to a pocket and are of rather unusual design in that the cage ends form a flange and project beyond the end of the connecting rod. It was found by experience that bearings of this design are less subject to burning on the side thrust faces.

The center crankshaft bearing, No. 3, is also a caged roller bearing but in this bearing there are three rollers to a pocket and the retainer cage is narrower than the outer race. One thrust face is stationary while the other is rotating with the shaft. The advantages of this bearing are that it is easy to assemble, the retainers are stamped from flat steel and the ends of the rollers do not wear against the thrust faces.

The bronze wrist pin bushing, bearing No. 4, follows good design practice wherein the hardened steel of the wrist pin is running against the bronze bearing. This bearing forms a good guide, is low in cost, light in weight, and is easy to maintain. In some instances this type of bearing is superior to an anti-friction bearing since it is not critical to alignment and is not subject to rusting in the presence of moisture.

Bearing No. 5, the drive shaft bearing, like No. 4, is a bronze bushing with a steel shaft running against it. This bearing forms a steady-rest for the long shaft connecting the pinion gear and crankshaft. Its importance lies in aligning the shaft seal and the water pump.

The pinion bearing, No. 6, is a tapered roller bearing which is capable of carrying both the high radial and thrust loads which are imposed by the heavy loading of the pinion gear.

No. 7 is also a tapered roller bearing which was chosen because of the ability of this comparatively small bearing to carry a high thrust load.

As a final type, No. 8 is a ball bearing which absorbs a high radial load while having a relatively small axial length.

Courtesy Kiekhaefer Corporation

Figure 6 — Piston and connecting rod assembly: note use of roller bearings in both crank and piston end of connecting rod.

COOLING

Cooling has a very important effect upon the operation of an outboard motor and any temperature extreme is undesirable. Water is used as the coolant in most cases, but air cooling may be used effectively where the engines are designed to power chain saws, pumps, lawn mowers, etc. The temperature of the water in which the motor is used is probably the one most important factor in determining the temperatures at which the engine will operate. However, this temperature may be influenced by design features, such as the size of the water passages, the size and/or speed of the water pump, the use of siphon or by-pass systems or even thermostats.

The use of thermostats in outboard motors has been considered many times, but there are attendant problems that have not been satisfactorily answered. One of the main difficulties is that the cooling system is not closed so that control similar to that employed in the automobile is impracticable. Cold water is always entering and heated water is always discharged, so that the desired heat balance is difficult to achieve. A second difficulty is that the metallurgy of the thermostats must be considered when operation in salt water is contemplated, since corrosion is much more severe and the efficiency of the thermostat is thus more quickly impaired.

As mentioned above, extremes of temperature are undesirable, since poor performance can be as readily experienced when the temperature is too low as when it is too high. In Figure 7 it will be noted that there is a considerable difference in the incidence of spark plug fouling; more difficulty was experienced in the engine which had the higher

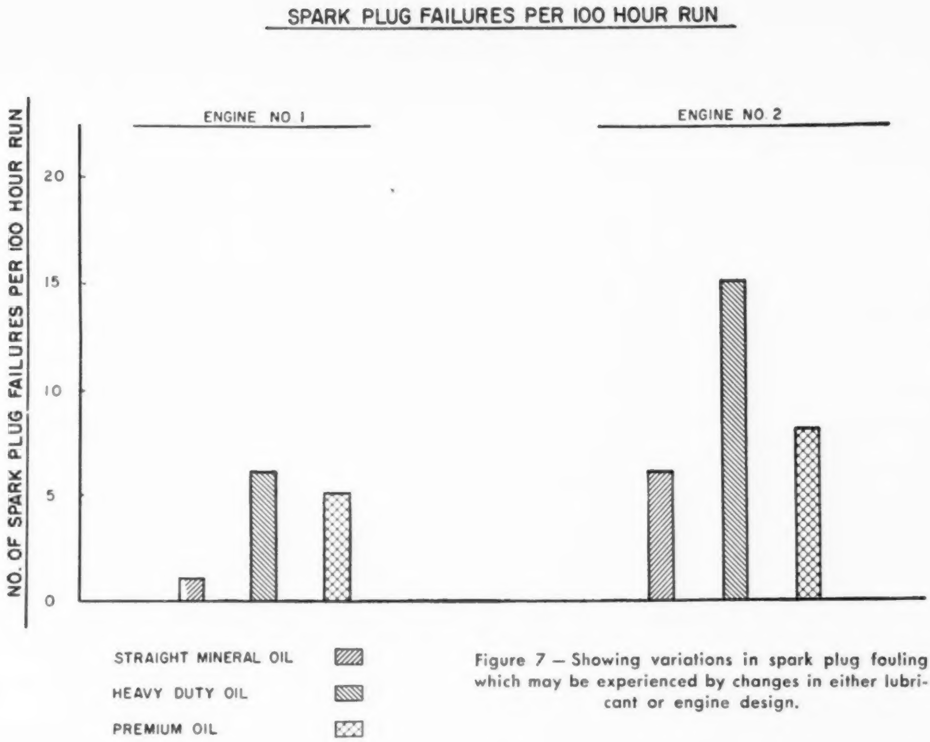


Figure 7 — Showing variations in spark plug fouling which may be experienced by changes in either lubricant or engine design.

operating temperatures as measured by spark plug gasket thermocouples. This was verified in several engines of the same make and model while other variables were held constant. At the other extreme field experiences indicated that operation in cold water may lead to soft sludge formation within an engine. While it is not normally within the power of the operator to change the operating temperatures of an engine to any appreciable extent, it is felt that awareness of the influence of temperature upon performance may lead to better care of the cooling system.

FUELS

The octane requirement of outboard engines is well below the octane that is generally available in marine white or regular grade automotive gasolines. This means that the engine should operate without a knock or ping under normal conditions when either of these fuels is used.

The white gasolines marketed for marine service are high quality fuels manufactured for use primarily in marine inboard engines rather than outboard motors. These gasolines have a high octane number, excellent storage stability (even in the presence of copper) and will resist the formation of gum over long periods. These fuels should not be confused with the white colored gasolines marketed in some areas for use in stoves or tractors, these gasolines contain no tetraethyl lead, but this may be all that the two grades of fuel have in common. The lower priced fuels are often just as the price implies, a third grade product which costs less to manufacture and will give relatively poorer performance in internal combustion engines. These fuels have low octane together with poorer storage stability, and may have gum forming tendencies in the tank and deposit forming tendencies in the engine.

The composition of gasoline varies considerably from location to location, and it may in combination with operating conditions exert considerable effect upon performance and deposits within the engine. Such a condition is sometimes found in the Pacific Northwest where the combination of the cold water and the fuels produced in that area, together with operation under low speed and low load conditions, leads to the formation of rather soft sludge deposits in the crankcase and on the connecting rods and bearings. In time these deposits will harden and stop the engine. This phenomenon is not limited to any make or model of engine, or brand or grade of gasoline.

As noted above, the octane requirement of the modern outboard is well within the range of present-day regular automotive gasoline. While the trend in the automotive industry is to increase the compression ratio of the engine, which in turn increases the octane requirement, this trend is not

carried over into the outboard motor field to any appreciable extent. In specialized cases, such as racing, the compression ratio may be increased, but there are other effects, such as harder starting and poor low speed operation, which has made it unattractive up to this time as an overall direction in which the manufacturers should proceed.

In their continuing desires to make the outboard even more convenient to operate, most of the leading manufacturers have provided for a larger fuel supply by supplying connections for the attachment of a five gallon tank. The interesting part of this development is that several methods of supplying the fuel mix to the carburetor are employed. Schematic diagrams and pictures shown in Figures 9-13 illustrate the essential features of these different systems.

In one system the flexing of a diaphragm in the fuel line acts as a pump to supply fuel at all times to the carburetor. Once the line is filled (a small bulb is included in the fuel line to fill the system initially) the alternating change of pressure in the crankcase alternately draws new fuel into the line and then forces it to the carburetor.

In a second system the fuel is forced by the operator to the carburetor, so that the engine may be started. Once started the pressure is maintained by the engine. This system requires a twin hose, one maintaining pressure to the tank, and one carrying fuel from the tank.

A third system, somewhat more typical of that found in your automobile, uses a pump, the lever of which is activated by the eccentric on the magneto drive idler gear.

EFFECT OF TETRAETHYL LEAD

The question often arises in the field regarding the effect of tetraethyl lead on engine performance. To evaluate this effect in the laboratory, runs were made for extended periods in different makes of engines of approximately five horsepower, holding conditions constant, except for varying the amounts of tetraethyl lead from zero to three ml per gallon. These tests indicated that there were significant increases in spark plug fouling with increases in tetraethyl lead content. The same tendencies were exhibited in all engines although to a varying extent. As an example two different makes of engines

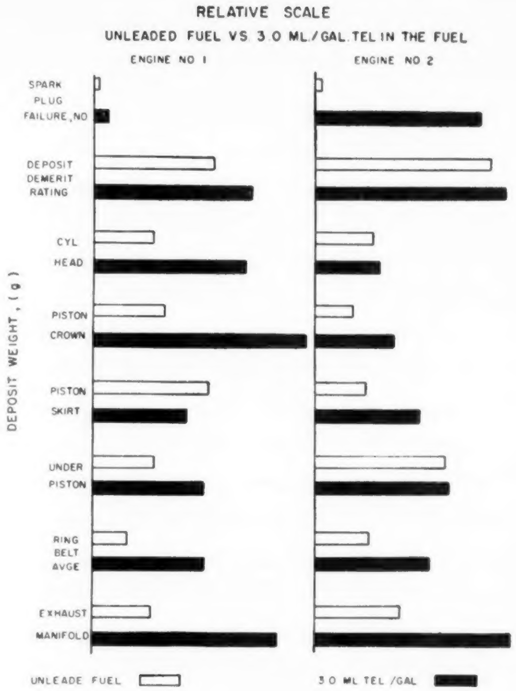


Figure 8 — Graph showing how differences in deposits and spark plug fouling may result from variations in TEL content.

each completed a one hundred hour test on a fuel containing no lead, with no spark plug failures. In one of these engines, at the end of the test, both plugs were in good condition although there were light, black, oily deposits and slight electrode erosion. In the other engine the plugs also were in good condition but the oily deposits were not so noticeable. In additional tests in the first engine, using the same fuel to which had been added three ml of tetraethyl lead per gallon, twelve spark plug failures occurred. In the second engine, only one plug failure occurred when the fuel was leaded to three ml's, but this plug showed signs of electrode erosion and appeared to be core bridged.

This effect of tetraethyl lead on spark plug fouling has been discussed at some length, since plug fouling is one of the effects noticed by the operator as an immediate cause of engine failure.

Courtesy Johnson Motors

Figure 9 — View of gasoline tank showing essential features.

Courtesy Johnson Motors

Figure 10 — Schematic view of fuel system in which the fuel tank is pressurized from crankcase. Twin hoses are necessary.

Courtesy Kiekhaefer Corporation

Figure 11 — Schematic view of system layout using automotive type pump. 2 — Transfer line coupling. 4 — Fuel filter. 6 — Fuel pump. 8 and 10 — Carburetors. 12 — Pressure gauge. 13 — Primer. 15 — Check valve.

Courtesy West Bend Aluminum Company

Figure 12 — Schematic diagram indicating working principle of fuel system employing single hose.

Courtesy Scott-Atwater Manufacturing Company

Figure 13 — Fuel pump in which diaphragm is activated by changing crankcase pressure.

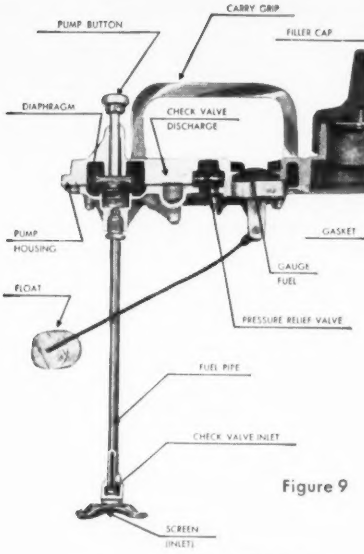


Figure 9

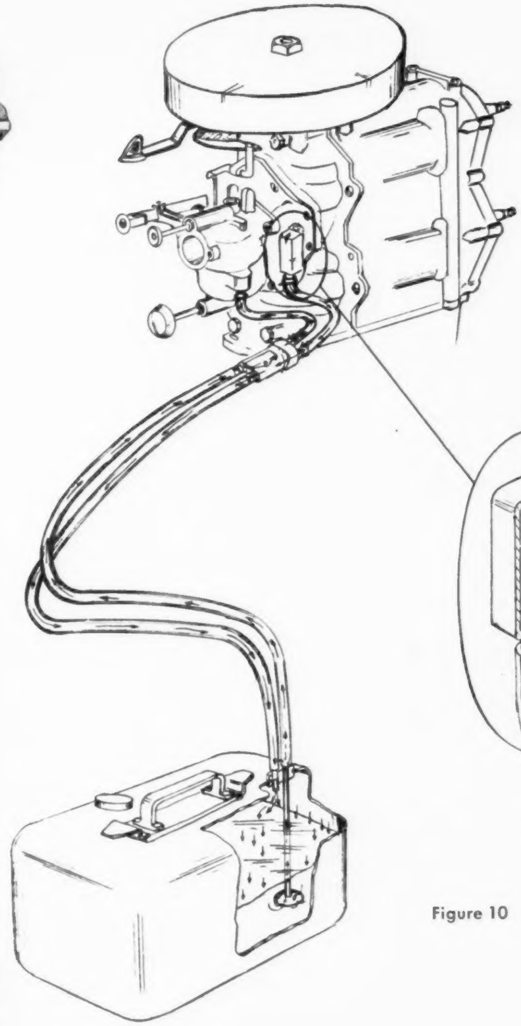


Figure 10

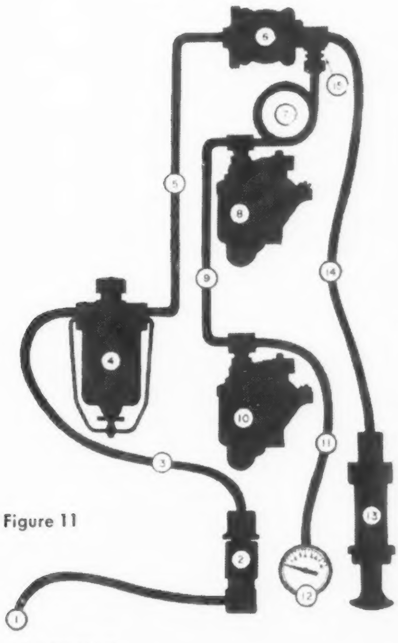


Figure 11

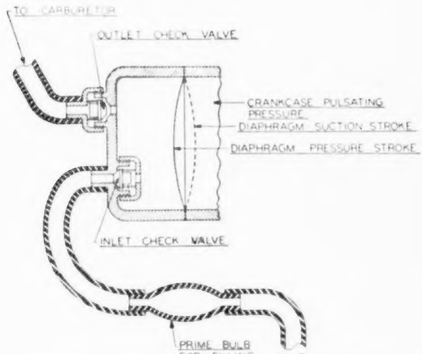


Figure 12

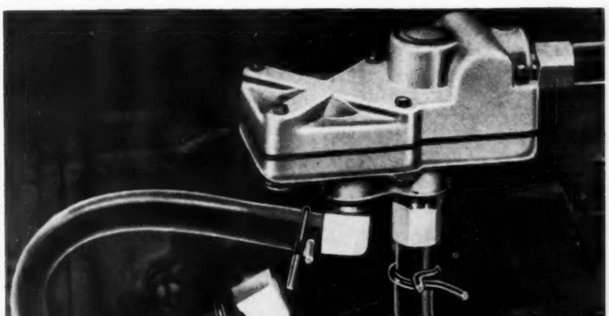
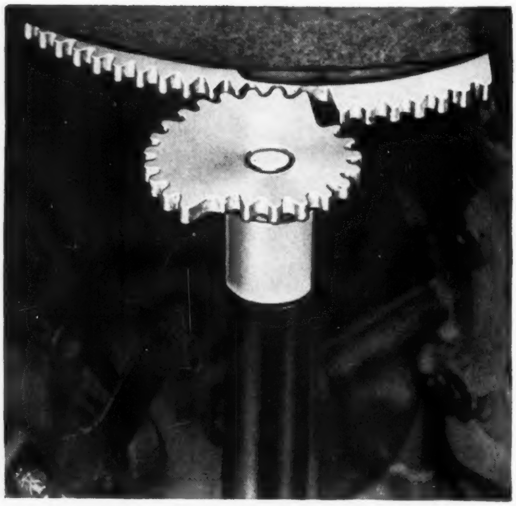


Figure 13



Courtesy Scott-Atwater Manufacturing Company

Figure 14 — To achieve two-stage synchronization the gear is cut in two arcs of different radii. When the gear moves on the stator plate in the higher speed ranges it operates on the smaller circumference so that spark and throttle can be advanced rapidly. During slow speed operation the gear engages the larger circumference which allows more precise control.

The effect of tetraethyl lead on other engine parts is shown graphically in Figure 8. From this figure it will be noted that there is considerable difference not only in spark plug fouling but also in the placement of deposits within an engine. These differences are believed due to the individual design features of an engine and may be expected to vary considerably according to make and model. Aside from the improvement in piston skirt cleanliness noted for Engine One, deposits in general become greater as the amount of lead is increased. This was also observed in air cooled two cycle engines powering other industrial equipment. This increase in deposits in many instances, however, is relative and does not affect the overall performance, or life of the engine between overhauls.

Tests conducted to determine the effect of continuous running versus intermittent operation indicated that more spark plug failures and demerit deposits were experienced under continuous operation than when the engine was stopped and allowed to cool between runs. Again there was considerable variation in both the amount of deposit and in the area of deposition.

SPARK PLUGS

Having commented upon the effect of tetraethyl lead and spark plug fouling, perhaps a word should be said concerning the plugs themselves. In a previous issue* it was noted that the position of the plug within the combustion chamber can greatly affect the performance of an internal combustion engine. Where high power output is desired a short controlled burning time is required and the plug is generally placed as near the center of the combustion chamber as possible, as exemplified in aircraft engines where two plugs are often used. Where good idling and high speed performance is required, a plug located near the intake is preferable so that a good combustible mixture is available; this is exemplified by many two-cycle engine designs. To reduce detonation tendencies plugs should be located near the exhaust side since this is usually the hottest region and the flame front can advance away from the plug towards the cooler region of the combustion chamber. The eventual position selected by the manufacturer is usually a compromise which he believes will give the best overall results.

*June 1949 issue magazine "Lubrication"

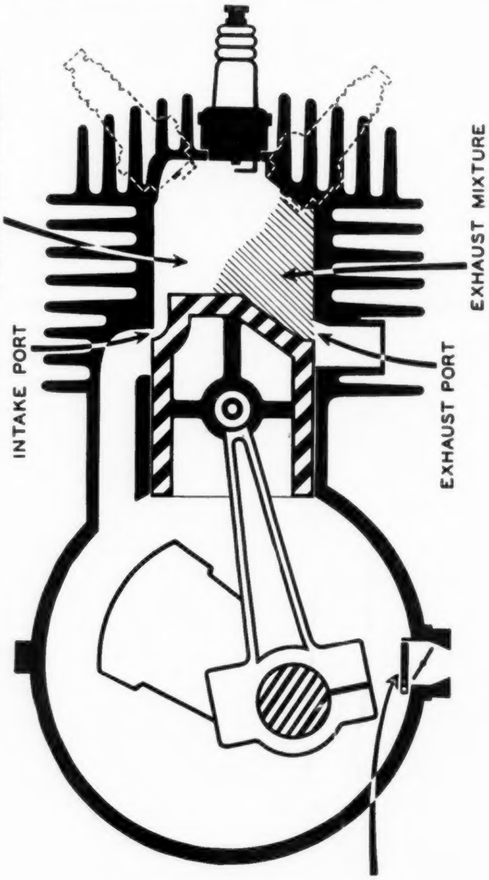
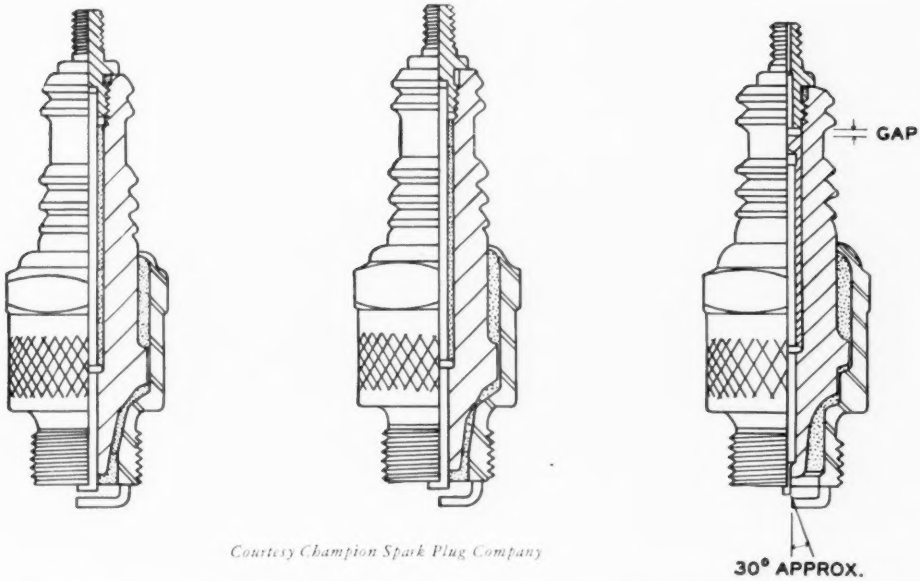


Figure 15 — Dotted lines show possible positions of spark plug within the combustion chamber which may be investigated by the manufacturer to secure increased power and improved performance.



Courtesy Champion Spark Plug Company

Figure 16 — Progress in spark plug design is shown above, plug at the right representing an advanced design which has been found to give improved performance in several two cycle engines.

It had been noted that under certain conditions the position of the electrode in relation to the combustion chamber apparently had some effect upon performance. This factor was investigated during rather extended hours of operation but no effects that could be ascribed to the position of the electrode were indicated.

Factors within the plugs themselves can affect operations considerably, and a good deal of time and money is being expended in research to secure even better performance. In any field it is difficult to state that there is only one best way, and this is true in the field of spark plugs. Three types of plugs commonly used in two cycle operation are shown in Figure 16. The plug to the left is commonly recommended for automotive use. The center plug has had the ground electrode cut back to reduce the area in which a filament or gap bridge could occur. The plug to the right has a smaller center electrode of platinum and the ground electrode has been cut back to the point where there is a 30° angle between the ends of the electrodes to still further reduce possibilities of gap bridging. In addition this plug has a reduced opening which offers a smaller target to flying particles within the combustion chamber. A gap in the center electrode reduces the possibility that "maverick" voltages will cause an unwanted spark. It is believed this condition occurs when the residual electrical energy is sufficient to produce a spark when the interrupter makes contact rather than breaks contact as desired in normal timing. These changes in geometry and materials illustrate the way in which the quest is continually being pressed so that better performance can be secured through advances in spark plug geometry, ceramics, and metallurgy.

OIL

Lubricating oil base stocks are generally classified as being either paraffinic or naphthenic, depending upon the chemical structure of the main components. These differences in chemical structure with the attendant differences in physical characteristics lead to differences in performance within an engine. Paraffinic stocks have a lower volatility, and will generally furnish a satisfactory lubricating film at higher piston and cylinder temperatures. Upon burning, however, they tend to form harder carbon deposits. Naphthenic stocks have a higher volatility which results in their being flashed off the piston and cylinder walls more easily, which may leave an inadequate film under borderline conditions, and this may in turn lead to higher piston ring and cylinder wear. In their favor the carbon deposits formed from naphthenic stocks tend to be lighter and softer and do not build up in the engine as rapidly. It may thus be seen that each base stock has desirable properties which the refiner must consider when processing a lubricating oil so that the utmost in performance is available to the consumer.

In addition to the type of base stocks, consideration must also be given to the selection of additives that may be employed either to improve certain natural properties of the oil or to impart additional desirable characteristics. Automotive oils have up

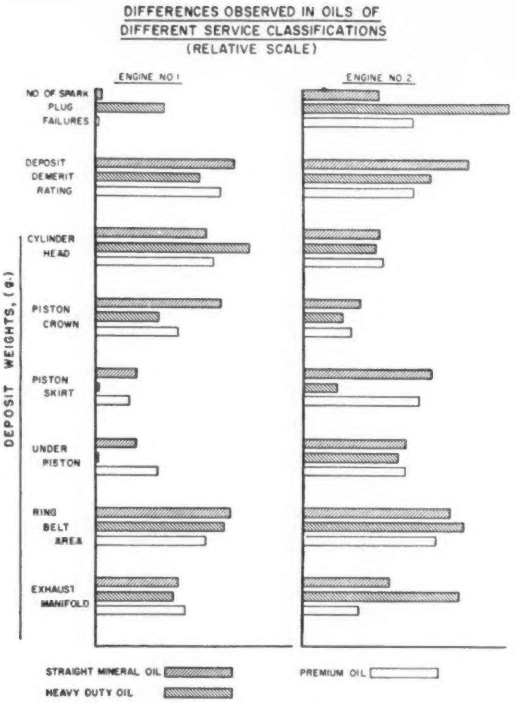


Figure 17 — Bar graph showing variations in deposits and spark plug fouling as experienced in different engines using oils manufactured for different service classifications, Straight Mineral Oil referred to as Oil A, Premium Oil as Oil B, Heavy Duty Oil as Oil C.

until very recently been classified by the American Petroleum Institute as follows:

"Regular Type — This term designates motor oil generally suitable for use in internal combustion engines under moderate operating conditions."

"Premium Type — This term designates motor oil having the oxidation stability and bearing corrosion preventive properties necessary to make it generally suitable for use in internal combustion engines where operating conditions are more severe than regular duty."

"Heavy Duty Type—This term designates motor oil having the oxidation stability, bearing corrosion preventive properties and detergent dispersant characteristics necessary to make it generally suitable for use in both high-speed diesel and gasoline engines under heavy duty service conditions."

The American Petroleum Institute, however, has now approved new classifications based upon the service in which the oils will be employed. These new classifications are as follows:

"Service ML — Service typical of *gasoline* and other spark ignition engines operating under *light and favorable service conditions,* the engines having no special lubrication requirements and having no design characteristics sensitive to deposit formation."

"Service MM — Service typical of *gasoline* and other spark ignition engines operating under *moderate to severe service conditions,* but presenting problems of deposit or bearing corrosion control when crankcase oil temperatures are high."

"Service MS—Service typical of *gasoline* or other spark ignition engines operating under unfavorable or *severe types of service conditions* and where there are special lubrication requirements for deposit or bearing corrosion control, due to operating conditions or to fuel or to engine design characteristics."

"Service DG — Service typical of *Diesel* engines in any operation where there are *no exceptionally severe requirements* for wear or deposit control due to fuel or to engine design characteristics."

"Service DS — Service typical of *Diesel* engines operating under *extremely severe conditions* or having design characteristics or using fuel tending to produce abnormal wear or deposits."

Correlation between these two systems of classification may generally be expressed as shown below:

Service M(otor) L(ight)	—Regular
Service M(otor) M(oderate)	—Premium
Service M(otor) S(evere) and D(iesel) G(eneral)	—Heavy Duty
Service D(iesel) S(ervice)	—No former classification (met by Supplement One and Series 2 Oils)

The classifications noted above concern only the quality and performance expected, and have nothing to do with the so-called body or viscosity of an oil. The viscosity is expressed as an SAE grade (that is SAE 10W, SAE 20, etc.) which conversely does not relate to quality.

Due to the fact that oils meeting classifications ML through MS-DG are generally available through both marine outlets and automotive service stations, a further word on these oils is warranted. Outboard motor oils will generally fall within the classification ML or MM, and usually are straight mineral oils or oils containing only a moderate amount of additive. The types of additive commonly known as detergents, used to promote cleanliness in engines, add very little to the overall cleanliness of outboard motors and some even may have deleterious effects.

The effect of additives on engine performance was studied in different makes and models of en

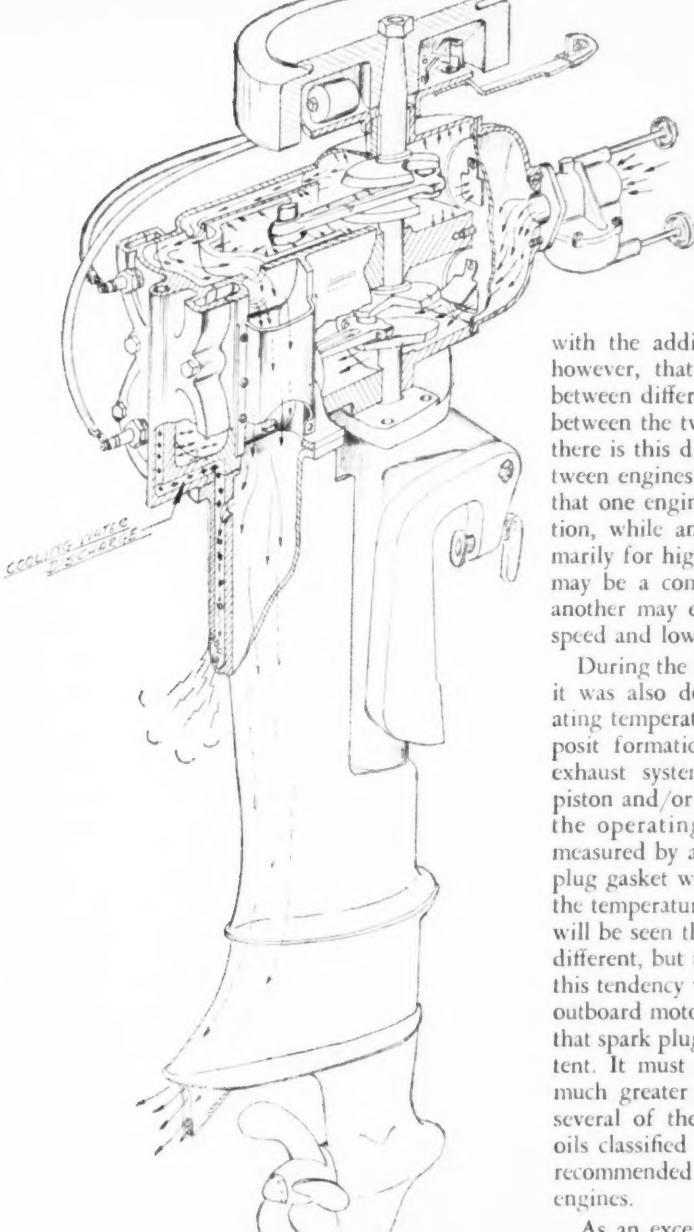


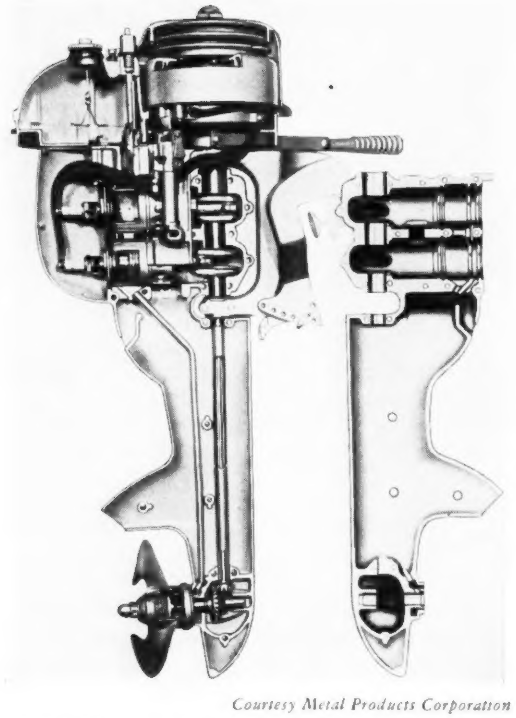
Figure 18—Schematic drawing showing the path of the air through the engine from the time it enters the carburetor. Included are induction, scavenging, exhaust relief, and underwater exhaust. Partial path of cooling water is also indicated.

Courtesy Johnson Motors

gines and the results are shown graphically for two engines in Figure 17. Oil A is a straight mineral oil, classified as regular, or for ML service, Oil B contains a moderate amount of additive and would be classified as a premium oil for MM service, Oil C would be classified as a heavy duty motor oil for MS or DG service. From these results it can be seen that spark plug fouling varied directly with the additive content. It should be noticed, however, that there was actually more variation between different makes of engines than there was between the two different levels of additives. That there is this difference in response to additives between engines is not strange when it is considered that one engine is designed for high speed operation, while another engine may be designed primarily for high load carrying capacity; still a third may be a compromise between the two, and yet another may exhibit its best characteristics at low speed and low load.

During the investigation of the effect of additives it was also demonstrated convincingly that operating temperatures affected spark plug fouling, deposit formation in the combustion chamber and exhaust system, and susceptibility to seizure of piston and/or bearings. In Figure 17, for instance, the operating temperature of Engine Two as measured by a thermocouple attached to the spark plug gasket was approximately 125°F. hotter than the temperature in Engine One. From this graph it will be seen that not only are the levels of deposit different, but the place of deposition varies. When this tendency was checked in a number of different outboard motors the same pattern emerged, namely that spark plug fouling increased with additive content. It must be remembered that this effect was much greater in some engines and is affected by several of the many variables. As a general rule oils classified for MS, DG, or DS service are not recommended for continuous service in two cycle engines.

As an exception to this general observation the characteristics of Heavy Duty Motor oils can be used to advantage in specific cases. One of the favorable characteristics which they offer is rust proofing protection to metal surfaces with which they come in contact. This factor is particularly valuable to the operator since it protects his investment during periods when the motor is not being used. Oils specifically manufactured for rust proofing purposes are known as Engine Preservative Oils. The prototypes of these oils were devel-



Courtesy Metal Products Corporation

Figure 19 — One of the interesting features of this engine is that the housing is split on the center line to permit easy access for cleaning and repair purposes.

oped to protect the engines in military vehicles during lay-up periods. These preservative oils must meet extremely exacting specifications and afford excellent protection to crankshaft, bearings, pistons, and cylinders against rust and corrosion for extended periods. During recent years Engine Preservative Oils have been used by several of the outboard motor manufacturers to protect the engine in the interval between production and sale. These oils are not generally available to the public. However since Heavy Duty motor oils offer the same type of protection against rust and corrosion during periods of storage, although for less extended periods, they are recommended for use in the fuel mixture during the period just prior to lay-up as a preservative oil when preparing the motor for periods of inactivity.

Lubricating Requirements

While outlining a research program it had been noticed that there was a wide variation in the lubricating requirements of different engines (variation from $\frac{1}{3}$ of a pint to 1 quart per gallon). The manufacturers were aware that such a condition was undesirable and individually they had expressed the hope that such variations in the field eventually could be eliminated. It appeared that the introduction of the improved auxiliary fuel tank offered an opportunity for specifying a set amount of oil, at least for all models of one manufacturer, as the first step in unifying the recommendations of the whole industry.

It was to investigate this question that tests were run on several different makes of engines under conditions which were felt to be more severe than would normally be encountered in the field. During these tests the amount of oil in the mixture was varied between $\frac{1}{3}$ quart per gallon and 1/5 quart per gallon in oil grades SAE 30 and SAE 40. Previous work had indicated that it was inadvisable to use an oil with a viscosity below that normally found in SAE 30's. Increasing the amount of oil would not give lubrication protection when low viscosity oils were used and it was indicated that an oil as light as an SAE 10 would not give an adequate lubricating film when used in the highest

Courtesy Martin Motors

Figure 20 — Split drive shafts are enclosed within spring. Twisting of the steering handle drops latch which contacts tab attached to upper portion of the spring. This causes the spring to "uncoil", which releases the lower shaft and it ceases to turn. Raising of the latch reverses the process and positive drive is again established. This unit operates entirely in a bath of oil.

Courtesy Champion Motors Company

Figure 21 — The "Hydro-drive" unit is essentially a positive displacement pump which is used as c hydraulic clutch by regulating intake and discharge ports. In the neutral position the intake is closed and the discharge open. As the Hydro-drive Control Lever is moved ioward the conventional drive position, the intake is gradually opened and the discharge closed so as to create a positive driving pressure. In the conventional drive position the mechanical lock comes into place so that there is no slippage under maximum power. After passing the neutral Hydro-drive position, the control pin engages a spring clutch for reverse.

Courtesy Evinrude Motors

Figures 22-23 — Cross section and exploded view of lower gearing incorporating two separate clutch systems, both of which are mounted on the propeller shaft. One of these, the neutral clutch, is activated by a coiled clutch drive spring which grips front and rear clutch drums. Normal rotation tightens spring so that no slippage occurs. Spring grip is released by depressing clutch lever. The second clutch provides propeller protection in case of obstructions. In this case the clutch slip rings which are fitted in slots in the propeller shaft are slightly wound up, reducing the outside diameter of the slip ring, which in turn reduces pressure between slip ring and rear clutch drum and thus permits impact to be absorbed when the propeller is stopped. Once the obstruction is removed the grip is again established. If the propeller is jammed the clutch will slip momentarily but will then stall the engine so that undue wear and/or motor strain is avoided.

Courtesy West Bend Aluminum Company

Figure 24 — Neutral is achieved through the use of a cam which controls the engagement or disengagement of dogs, one of which is on the bevel gear, the other of which is connected to the propeller shaft.

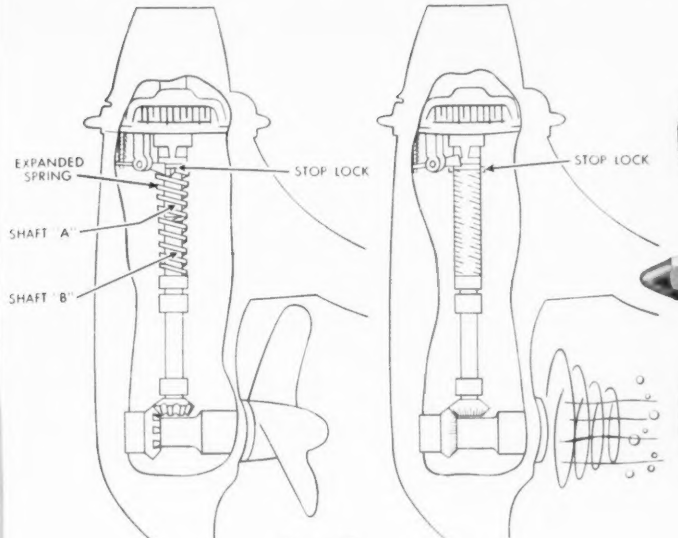


Figure 20

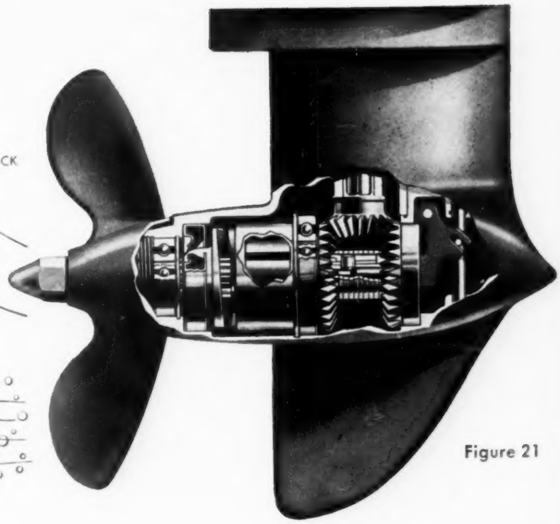


Figure 21

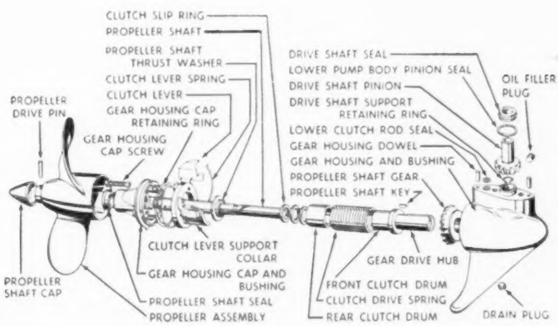


Figure 22

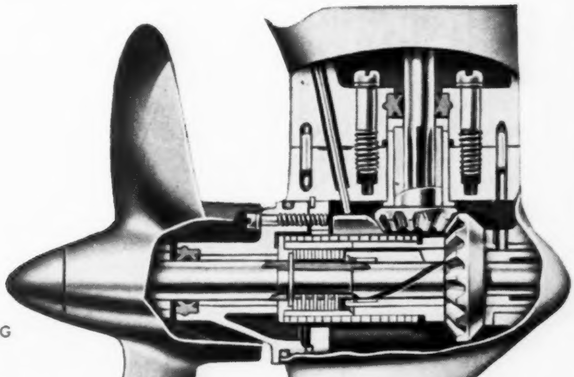


Figure 23

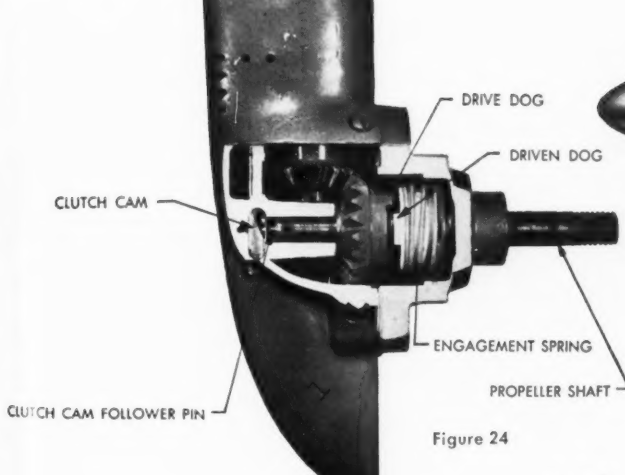
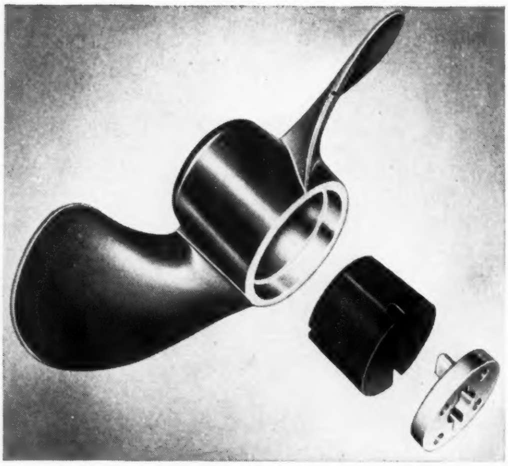


Figure 24



Courtesy Scott-Atwater Manufacturing Company

Figure 25 — The rubber cone permits the shear pin a turn of approximately 180° when propeller movement has been halted by an underwater obstruction.

percentage that would still give a combustible mixture. At the other extreme there was little justification for using an SAE 50 in these tests as the SAE 30 and SAE 40 grades provided satisfactory lubrication.

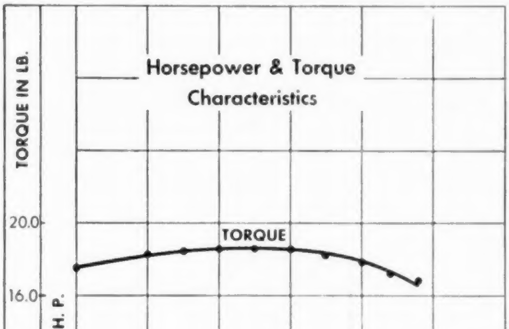
The data from these tests confirmed that there was a considerable variation in lubricant requirement between different engine makes and models so that a recommendation for a given amount of oil for all engines was not practical. The test work did indicate that increasing the amount of lubricant in the fuel mix would help to alleviate difficulty in those cases where borderline lubrication was experienced. It is felt that it is still safest to follow the manufacturers recommendations as to quantity. As of this year, several of the manufacturers are recommending the same quantity of lubricant for all of the models of their own manufacture. A certain amount of judgment should be followed when purchasing blended fuels to insure that there is an adequate minimum of lubricating oil present, and inquiry as to the proportions is often well repaid. Reputable dealers are conscientious in their proportions and mixing practices and will not resent an inquiry on the part of the operator.

A question that often arises concerns the many products on the market that are recommended as an addition to outboard motor oils. The best that can be said of practically all of those now on the market is that they may not harm your motor. It is felt that this statement is very generous since there are products falling within this classification that will definitely detract from both performance and engine life. Occasionally there will be one that seems to offer promise only to find upon more thorough and extended investigation that other ill-effects are experienced by the motor. It may be stated generally that refiners market finished products which experience and research have indicated will insure the best performance. If and when better performance can be obtained through the addition of certain materials, they will be added at the refinery. Dependence should not be placed upon the chance union of oil and chemical to improve performance.

GEARS, SHIFTS, CLUTCHES, ETC.

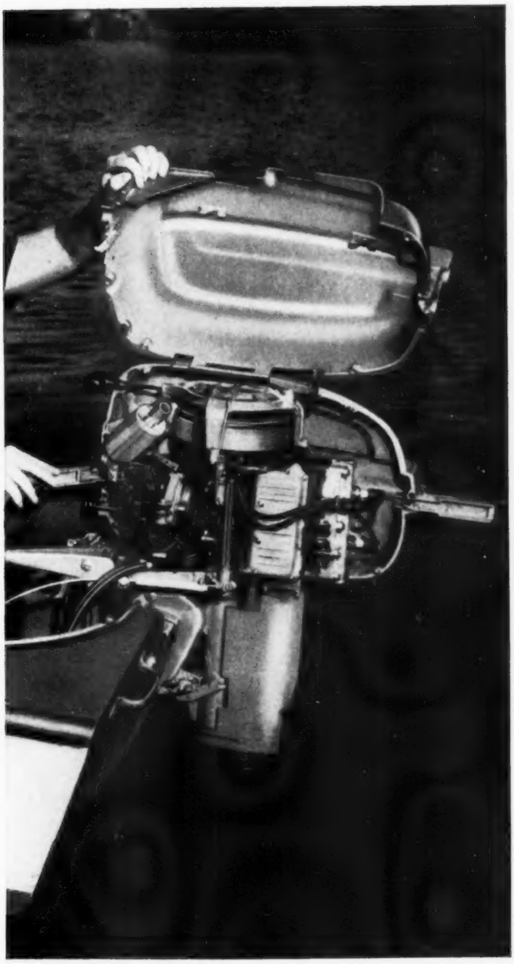
The power of the engine is delivered by the vertical crankshaft or its extensions to a pinion gear mounted on the lower end, which in turn drives a bevel gear attached to the propeller shaft.

The shift with which the present-day motor is equipped is the modern application of an old principle. Before shifting models were available the direction in which the propeller turned (clockwise or counter clockwise) was dependent upon the position of the bevel gear in relation to the driving pinion. This position was often determined by the space available to the designing engineer. The shifting units go one step further, having bevel gears which are attached to the propeller shaft, both ahead and behind the pinion. The direction of propeller rotation is thus dependent upon which bevel gear is selected by the operator. The neutral posi-



Courtesy West Bend Aluminum Company

Figure 26 — Using different lubricants, variations of up to 150 rpm were obtained.



Courtesy Evinrude Motors

Figure 27 — "Auto lift hood" which gives excellent access to engine for servicing, two snap clasps hold hood in place at other times.

tion results when the pinion is intermediate between the two gears. As an alternative to the shift some models have a neutral position which permits disengaging the propeller while the engine is still operating, however these systems do not allow reversing the propeller. The linkage and/or methods of control are ingenious and, as would be expected, vary considerably between manufacturers. The essential features of several of the methods are shown in Figures 20-24.

Protection must be provided for the engine and gearing in case an underwater obstruction prevents the movement of the propeller. This safeguard is most often secured through friction clutches which permit a sliding action between parts when propeller movement is halted. The clutches may employ plates, cones, or springs, and their use largely eliminates the use of shear pins.

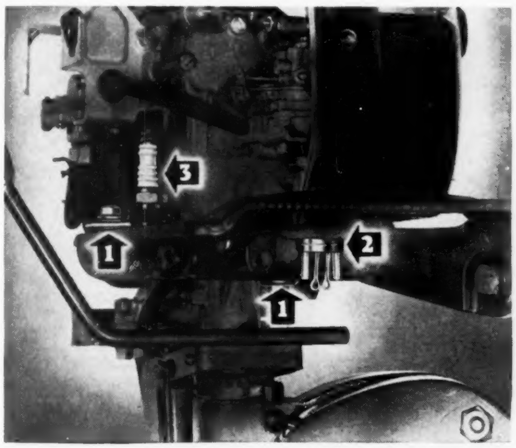
Gear Lubrication

A grease, a motor oil, or a gear lubricant having extreme pressure properties may be recommended by the manufacturer for use in the lower gear case.

The grease is usually a specially compounded product having low starting torque at low temperatures, adequate heat resistance to avoid thinning at higher temperatures, and water resistance to provide against water washing and rusting.

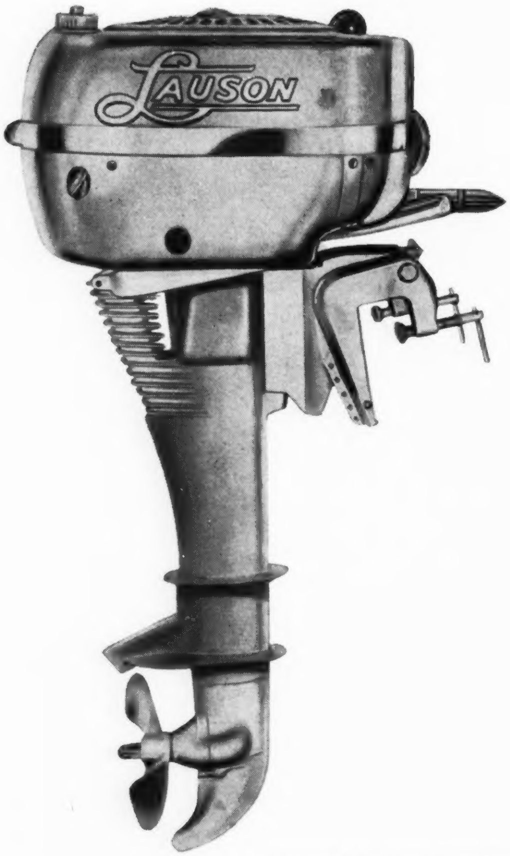
Outboard motor oils may be used for the lubrication of the gears in certain models. In these cases the seals employed in the unit usually have been improved to retain a fluid lubricant and to exclude water. The use of grease generally implies an inability to use a fluid lubricant, since the soap which is employed as an oil thickener adds little to the product from a lubricant standpoint.

The increasing use of extreme pressure lubricants in the shift models is mainly due to the improvement in seals as the pressure on the gears is not unusually severe. The use of EP gear lubricants has resulted in an improvement in performance however, for there has been a decrease in the number of gear complaints registered with the manufacturers. These complaints have always been very low in number, and the improvement is probably due to the improved break-in properties of modern EP lubricants and the improved rust and corrosion resistance that these lubricants possess. Some oils with extreme pressure properties form emulsions in the presence of water that still retain satisfactory



Courtesy Scott-Atwater Manufacturing Company

Figure 28 — Points marked 1 indicate positions at which steering bracket is attached to the motor. This bracket is suspended by rubber washers to absorb vibration. 2 is rubber mounting to hold spare shear and cotter pins. 3 — Spare spark plug holder.



Courtesy The Lauson Company

Figure 29 — Exterior view of four cycle outboard motor.

lubricating properties. In such cases the oil films prevent the water from coming in contact with the metal, and it is this ability to coat metals with a rust resistant oil film and at the same time hold any moisture present as an emulsion until it can be drained off that offers a decided advantage in gear protection.

Relation of Lubricant to Power Output

Since the question of horsepower is of great interest to everyone, anything which will increase the horsepower delivered by the unit is of importance. The graph (Figure 26) shows the horsepower curve for one small outboard motor. If the change in rpm when using different lubricants is plotted on the graph, it will be noticed that differences of approximately .05-.10 of a horsepower can be noted. This figure is not large and is indicated to be constant for any size motor; its importance is therefore limited to motors of small output. The graph is shown as an interesting sidelight only, indicating the avenues which are explored by the manufacturer to make the most power available from any given size power plant.

REMOTE CONTROLS

The newest outboard motor features which have been receiving considerable attention are the remote controls. The use of these controls will, to all intents and purposes, release the operator from the position in the stern of the boat. They are attached to the motor by snap-on connections that require no tools and thus afford the operator considerably more freedom of movement. As a matter of fact cruiser hulls are available now which have been designed for single and twin outboard installation and when using the remote controls offer all the conveniences of an inboard installation. By having the power source outboard rather than inboard a net saving of room has resulted, which on the water is a decided advantage.

STORAGE

The proper preparation of an outboard for storage during periods of inactivity is very important, and yet it is neither difficult nor time consuming. The cooling system should be flushed with fresh water, the fuel lines should be drained and the carburetor cleaned — do not leave any gasoline in the auxiliary tank, (any small surplus may be used in your automobile without any deleterious effects). The lubricant in the lower gear case should be changed to eliminate any water present. The spark plugs should be removed and dipped in heavy duty motor oil and one or two tablespoonsful of oil poured into each cylinder. The plugs should be replaced and the motor turned a few times to distribute a protective film of fresh oil over pistons, cylinder walls and gears. Having completed these preparations the motor should be wiped with an oily cloth and wrapped in heavy paper or canvas. When stored outboard motors should be kept in an upright position.

CONCLUSION

Both the manufacturer and the refiner are continuing their efforts to secure improved performance and increased economy for those who own and operate outboard motors. Through a better knowledge of how the outboard motor operates and greater attention to its maintenance the operator can join them and help himself to greater enjoyment on the water.

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